**INCIDENTAL FINDINGS ON CBCT BY FIELD OF VIEW AND PRESENCE OR ABSENSCE ON 2D IMAGING.**

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A thesis submitted to the faculty of the University Of Chapel Hill Adams School Of Dentistry in partial fulfillment of the requirements for the degree of Masters of Science in the diagnostic sciences department.

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**ABSTRACT**

Benjamin Crockett: INCIDENTAL FINDINGS ON CBCT BY FIELD OF VIEW AND PRSENECE OR ABSENCE ON 2D IMAGING.
(Under the direction of Donald Tyndall)

The purpose of this study was to quantify the frequency of incidental findings on cone beam computed tomography per field of view and determine which of these incidental findings was not visible on two-dimensional imaging. Significant incidental findings on 510 CBCT reports taken at the UNC Adams School of Dentistry were recorded. A subset of these findings were reviewed on periapical and panoramic imaging by board certified oral and maxillofacial radiologists to determine which findings were or were not visible. A significant portion of incidental findings detected on CBCT imaging were not visible on 2D imaging. CBCT volumes should be reviewed in their entirety in order to avoid missing any clinically relevant findings.

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# THESIS INTRODUCTION

Cone Beam Computed Tomography (CBCT) is a three-dimensional (3D) imaging modality that is used in dentistry to view the oral and maxillofacial region. CBCT has increased in use dramatically over the last decade in a multitude of different fields including oral and maxillofacial surgery, endodontics , orthodontics, periodontics, temporomandibular joint disorder and more (Almari et al. 2012). Its 3D look at the oral region provides an advantage over traditional two-dimensional (2D) imaging. Unlike CBCT, 2D imaging is limited by overlapping structures, magnification, minification and ghosting (Nakata et al 2006). When compared to other 3D imaging modalities such as multi-detector computed tomography (MDCT), CBCT has lower radiation dosage and is more easily accessible to dental clinicians. While it does have excellent hard tissue contrast such as in bone, it does not have good soft tissue contrast like MDCT (Mallya & Lam 2019).

CBCT images have variable fields of view (FOV). These may be small and encompass only a few teeth in the dentoalveolar region, or may be large and include a wider range of anatomical structures. The largest FOV will include the sinuses, airway, temporomandibular joint, skull base and soft tissues. As a result of this large area, a significant number of disease findings may be visualized. These findings may be of low significance such as anatomical variations or may be life threatening in case of a malignancy. A finding that does not relate to the reason for the scan is further categorized as an incidental finding (Deif et al 2019).

Diagnostic accuracy of diseases has shown improvement with the use of CBCT when compared to traditional 2D imaging in several areas. There are some areas however that have shown no or minimal improvement. Research on the difference in detection accuracy of CBCT versus 2D imaging has been completed on many of the more common dental diseases such as periapical periodontitis and periodontal disease, but there are a large number of findings with little to no research completed in the literature (Dutra et al. 2015) (Almeida et al. 2017).

In all current literature any finding that did not relate to the area of interest was considered an incidental finding. However, many of these findings may have already been visible on 2D imaging. Therefore, the goal this study was to determine how many of these incidental findings were truly incidental. That is to say how many could not be seen already. This study emphasizes the need to evaluate a CBCT volume in its entirety even if comprehensive 2D imaging has already been taken.

## REVIEW OF THE LITERATURE

### Literature Review Introduction

A full literature review was conducted using Pubmed through the UNC health sciences library. Search terms included "CBCT and Incidental Findings", "CBCT and Intraoral and Detection", "CBCT and Intraoral and Accuracy", and "CBCT and Intraoral and Comparison". Abstracts were read and articles that related to incidental findings found in CBCT and articles comparing the detection accuracy of CBCT vs intraoral radiographs where included.

### Incidental Finding Frequency in CBCT Introduction:

Large FOV CBCT volumes are able to view a large area of the oral and maxillofacial region. As the FOV increases there is also an increase in the number of anatomical locations that are included. As a result, there will also be an increase in the different types of incidental findings that will become visible. Several studies have researched the frequency of incidental findings in CBCT volumes. Some studies include all incidental findings in their totals while others focus on a specific area only. There was a wide variation in the frequency of findings from study to study for a multitude of reasons.

### Incidental Finding Frequency Systematic Review:

A systematic review by Dutra et al. reviewed ten articles on the frequency of incidental findings in large field of view CBCT images and found an overall frequency ranging from 24.6-94.3%. Incidental findings were separated into various categories which included airway, TMJ, vertebral, vascular, soft tissue calcification, dentoalveolar, endodontic, threatening, and pathological findings. Sample sizes ranged from 150-1000. A CBCT volume of at least 13cm or larger was used in each study. Only one study included a volume that was 6cm in size (Deif et al. 2019).

Airway findings included mucus retention cyst, concha bullosa, sinusitis, deviated septum and nasal polyp. TMJ findings included flat condylar margin, condylar degenerative change, condylar erosion, sub condylar cyst, osteophyte, and bifid condyle. Vertebral findings included degenerative changes. Vascular findings included calcification of atherosclerotic plaques in the carotid arteries. Soft tissue calcifications included tonsilloliths, sialolith, calcified stylohyoid ligament, and pineal gland calcification. Dentoalveolar findings included supernumerary teeth, periapical rarefying osteitis and root fragments. Endodontic findings included endodontic lesions. Threatening findings included malignancy. Pathological findings included dentigerous cyst, ameloblastoma, giant cell lesion, nasopalatine duct cyst and odontogenic keratocyst. Findings needed to be in at least two articles to be included.

There was a wide degree of variance in the frequency of findings in each category when comparing the 10 studies. The finding frequency range for each of the ten articles was as follows: airway (0.4 - 95.7%), TMJ (0.1 - 34.6%), vertebral (0.5 - 45.6%), vascular (2 - 5.7%), soft tissue calcifications (0.3 - 41.7%), dentoalveolar (0.4 - 41.2%), endodontic (0.4 – 11.8%), threatening (0.3 – 1.4%) and pathological (0.6 – 3.6%). The variation in frequency from study to study was a results of several factors. There was a lack of consistency when it came to the definition for each finding. Apical lesions were defined as periapical rarefying osteitis in some and endodontic lesions in others. In the Dutra at al. article these were separated. Several of the studies excluded certain findings that other studies did not. Some articles deemed some findings to be not clinically significant and were excluded while they were included in others. Several articles did not include dentoalveolar findings at all. There was also a variation in the reason for the scans with some studies focused on orthodontic patients and others on implant planning. There was a significant variation in the average age of patients imaged due to the difference in the reason for the scan. Older patients are likely to have more findings while younger patient or those undergoing orthodontic treatment will have fewer. None of the studies utilized the same CBCT unit. There was a variation in the exact FOV as well as the imaging parameters. Units with a larger voxel size may underestimate the total number of findings as they may not have been visible. Four of the studies used a single radiologist to review all images, four used two, and one used thirteen. With all of these variations between the studies it is difficult to compare and assess the true frequency of each particular incidental finding (Allaredy et al. 2012)(Caglayan & Tozaoglo et al. 2012)(Cha et al. 2007)(Drage et al. 2013)(Lopes et al. 2017)(Pette et al. 2012)(Pliska et al. 2011)(Price et al. 2012)(Warhekar et al 2015)(Zain-Alabdeen & Khateeb 2016).

**Incidental Finding Frequency Targeted Studies:**

A study by Damaskos et al. reviewed 700 CBCT scans to evaluate the frequency of extra- and intra-cranial arterial calcifications in adults. Extra-cranial and Intra-cranial calcifications were found in 150 (30.99%) and 161 (33.26%) of the scans. These calcifications were found more frequently in males and frequency increased with age. Calcifications of carotid arteries is clinically significant and from this study it was shown to appear in a substantial number of CBCT volumes (Damaskos et al 2014).

A study by Alsufyani reviewed 7689 CBCT scans to evaluate the frequency of cervical spine and clivus findings. There were 732 (9.5%) findings in this region with the most prevalent being degenerative changes in females. There were 37 developmental and pathological findings. This study concluded that findings in the cervical spine and clivus are rare, but can be clinically significant when present. Some of the more significant findings may be associated with an increased risk for subsequent neurologic compromise illustrating the need for potential referrals and imaging beyond CBCT (Alsufyani et al. 2017).

A study by Kuijpers et al. reviewed 187 CBCT volumes of patients with cleft lip and cleft palate and recorded the overall frequency of incidental findings in this patient demographic. It was concluded that patients with cleft lip and palate have an increase in the number of dentoalveolar and paranasal sinus findings when compared with the literature. It was concluded that as with all other CBCT scans, evaluation of the full volume is important (Kuijpers et al. 2013).

A study by Togan et al. reviewed 999 CBCT volumes and recorded the frequency of clinically relevant non-dental findings. A total of 350 significant incidental findings were found with the most frequent being paranasal sinus findings. This article concluded that the frequency of incidental findings outside the dentoalveolar region is high and complete examination beyond the area of interest is necessary (Togan et al 2016).

A study by Gracco et al and Pazera et al. evaluated 513 and 139 CBCT volumes of orthodontic patients for the prevalence of paranasal sinus findings. A total of 258 (50.3%) and 65 (46.8%) of the CBCT scans contained incidental findings. The most frequent finding was mucositis in both studies. 10.1% had the presence of pseudocysts. Both articles concluded that a high prevalence of maxillary sinus findings are found in the orthodontic population (Gracco et al. 2012) (Pazera et al. 2010).

A study by Raghav et al reviewed 201 patients for maxillary sinus pathology who also presented with dental problems. The prevalence of findings was 59.7%. Like in the previous two studies the most prevalent finding was mucositis. This article concluded that the relative number of findings in the maxillary sinus is high (Raghav et al. 2014).

A study by Avsever et al reviewed 691 CBCT scans for paranasal sinus and nasal septum variations. A total of 548 of the scans contained at least one incidental finding. While many of the findings required no follow-up there were still several findings of air-fluid level, sinus opacification, mucus retention pseudocyst, and Mucocele which were found in 42 patients. This study concluded that while most findings do not require follow-up there is still a significant number that clinicians need to be aware of and review in each scan (Avsever et al. 2017).

A study by Barghan et al reviewed 400 CBCT scans to evaluate incidental findings located in and around the skull base. Findings were categorized into cervical vertebrae, intracranial, soft tissue, airway, carotid artery, lymph node, and skull base findings. A total of 653 findings were found in 309 of the volumes. The majority of findings were soft tissue and artery calcifications. 31.24% of these findings required a referral and 17.76% required monitoring. This study concluded that a comprehensive review of CBCT scans is necessary to avoid missing any significant findings (Barghan et al. 2016).

**Incidental Finding Frequency Conclusion:**

A full review of the literature on the frequency of incidental findings in CBCT reveals that the overall total number of findings is high. Many of these findings are not clinically significant, but there is a still large portion that require follow-up or monitoring. In addition to a full review of each CBCT volume it is important to understand how to identify and properly manage each finding. Failure to do so will result in missed or mismanaged disease.

**Radiographic Diagnostic Accuracy Comparison of 2D vs 3D Imaging Introduction:**

Radiographic diagnosis in dentistry has traditionally been achieved using 2D imaging modalities. These include intraoral periapical and bitewings images and extra oral panoramic imaging. However, these modalities have some limitations. Dental structures may exhibit superimposition or distortion that will mask important disease findings. CBCT has the added advantage of imaging a larger area of the head and neck and in three dimensions which eliminates superimposition and distortion. Intraoral imaging is still advantages though as its resolution is generally higher than CBCT. Never the less, CBCT imaging still provides a high resolution that is capable of a high level of diagnostic accuracy. There have been many studies on the comparison of common dental diseases, but there is still a gap in the comparison of some less common diseases (Dutra et al 2015).

**Radiographic Diagnostic Accuracy Comparison of 2D vs 3D Imaging Apical Periodontitis:**

Micro-organisms in the oral cavity that have entered the pulp canal of a tooth will elicit an inflammatory response in the apical periodontium. This process is known as apical periodontitis. The apical bone will resorb as a defense mechanism in order to prevent further spread. As a results, a radiolucent region can be seen on a radiograph. Apical periodontitis is usually detected on radiographs because the disease is largely asymptomatic. Diagnosis has traditionally been achieved using conventional and digital projection radiography (CPR) (DPR). More recently however, CBCT has shown to have greater diagnostic accuracy. Lesions that are isolated to the cancellous bone are not consistently visualize which results in the possibility of much more extensive resorption than is apparent. Small field of view CBCT images have been suggested as the imaging modality of choice for patients who have nonspecific clinical symptoms (Dutra et al 2015).

A systematic review by Dutra et al. reviewed 9 articles on the comparison of CBCT with DPR and CPR in the diagnosis of chemically induce apical periodontitis. Overall the studies reviewed had an average ROC value of 0.96 for CBCT, 0.73 for CPR and 0.72 for DPR. This shows that the diagnostic accuracy of CBCT is improved over the other two 2D imaging modalities. Lesions that were located within the cortical bone were detected with greater accuracy over cancellous bone only. Diagnosis of lesions that were larger in size had greater accuracy. CBCT had higher NPV and PPV values which results in fewer false positives and a reduced risk of underdiagnoses. DPR and CPR showed low NPV and PPV values. Multiple other studies that were not included in the systematic review also showed improved diagnostic accuracy of CBCT over other 2D imaging systems (Campello et al. 2017) (Cheung et al. 2013) (Estrela et al. 2008) (Giudice et al. 2018) (Hansen et al. 2007) (Low et al. 2008) (Paula-Silva et al. 2009) (Venskutonis et al. 2014).

**Radiographic Diagnostic Accuracy Comparison of 2D vs 3D Imaging Periodontal Defects:**

Alveolar bone loss is a result of inflammatory mediators located in the periodontal tissue (Green et al 2019). Periodontal defects have a high prevalence worldwide (Bagis et al. 2015). Dentists have traditionally monitored alveolar bone loss using intraoral radiography, probing pocket depths and attachment levels (Green et al. 2019). These tools help to aid in the diagnosis of vertical periodontal defects and furcation involvement among others. Diagnosis of more advanced periodontal defects using these measures is challenging. Conventional imaging provides a 2D image that is limited by overlapping and superimposition of structures, distortion and blurring leading to a decrease in diagnostic data. Studies have indicated that intraoral radiography underestimates the amount of bone loss. Defects that are located on the lingual or buccal side of a tooth were underdiagnosed. (Bagis et al. 2015). Accurate diagnosis was only possible with direct vision during surgical procedures and is necessary for proper periodontal therapy. CBCT allows for a 3D look at the surface of the bone which could improve proper treatment planning for periodontal therapy (Bayat et al. 2016). Multiple studies have shown that CBCT improves diagnostic accuracy for some, but not all types of periodontal defects. CBCT is a useful adjunct, but not a replacement for current diagnostic tools (Bayat et al. 2016) (Bagis et al. 2015) (Green et al. 2019) (Almeida et al. 2017) (Kamburoglu et al. 2015) (Noujeim et al. 2009) (Zhang et al. 2018).

**Radiographic Diagnostic Accuracy Comparison of 2D vs 3D Imaging Root Resorption:**

The loss of cementum and dentin of a tooth root as a result of odontoclastic activity is termed root resorption. This process may start internally or externally. The resorption process may be short lasting only a few weeks or longer with continued pressure and infection. With 2D imaging, internal and external root resorption may be challenging to properly diagnose. An accurate diagnosis is necessary for proper treatment planning. Internal root resorption appears as an expansion of the pulp canal. External root resorption varies in appearance from a cloudy radiolucency to an irregularly shaped lesion. Diagnosis can be improved by using two intraoral images at different angles to localize the lesion. This however may not give an accurate representation of how far the lesion has progressed, the actual size, or the location. As a result this may lead to improper diagnosis. CBCT has been used more recently to better assess the resorption process in a 3D space. In multiple studies, CBCT was shown to improve the diagnostic accuracy of the type of resorption as well as increase the percentage of case that achieved proper patient management (Patel et al. 2009)(Bernades et al. 2012)(Durack et al. 2010)(Shokri et al. 2013)(Liedke et al. 2009).

**Radiographic Diagnostic Accuracy Comparison of 2D vs 3D Imaging Vertical Root Fractures:**

Vertical root fractures are a classification of fracture that involve only the roots of teeth in a vertical dimension. They most often affect endodontically treated teeth and fracture as a result of weekend tooth structure and heavy masticatory forces. The fractures can originate from any level on the tooth root and progress in any direction. Diagnosis usually occurs much later in time after endodontic treatment when symptoms arise. Most often other radiographic signs will be evident before a fracture becomes visible. These signs appear as a combined periapical lesion that progresses up the side of the root surface in a “J” shape. Therefore, intraoral radiographs are used to view signs of fractures rather than the fractures themselves. A systematic review by Corbella et al. concluded that CBCT does not provide any improvement on the visualization of vertical root fractures in vivo (Corbella et al. 2014). However, there were several other studies that did show an improvement in diagnostic accuracy using CBCT (Avsever et al. 2017) (Bechara et al. 2013) (Bornstein et al. 2009) (Varshosaz et al. 2010) (Wenzel et al. 2009). Accuracy is dependent on voxel size and lesion location (Wenzel et al. 2009). CBCT does aid in proper management of the patient by providing other information relative to the patients dental needs.

**Radiographic Diagnostic Accuracy Comparison of 2D vs 3D Imaging Sinus Pathology:**

A number of common sinus pathologies can arise including sinusitis, mucus retention pseudocysts, nasal polyps, cyst, and tumors. Symptoms of sinus pathology often present themselves before they are radiographically visible on panoramic imaging. Many sinus findings do not require any treatment or follow-up, but there are many that due such as the case of tumors, cysts, and more severe sinusitis. Detection of tumors are cysts is necessary for proper referral and treatment. Assessment of the maxillary sinus prior to sinus surgery is also necessary to reduce complications. Therefore accurate radiographic assessment is necessary for proper patient planning. A study by Altzinger et al. found that panoramic imaging was sufficient in most cases of diagnosis of sinus pathology with the exception of cysts pushing into the sinus (Altzinger et al. 2015). A study by Dau et al. found that panoramic imaging was not sufficient in diagnosis of symptomatic sinus pathologies and also heavily relied on clinician experience (Dau et al. 2017). A study by Rosado et al. found that sinus pathology diagnosis improved with CBCT when used by dental students (Rosado et al. 2019). The current literature is mixed on the reliability of panoramic imaging for sinus pathology diagnosis and may be dependent on clinician skill rather than the imaging modality.

**Radiographic Diagnostic Accuracy Comparison of 2D vs 3D Imaging Conclusion:**

Several studies in the literature are available for a few of the more common dental diseases. There is a lack of information on other less common incidental findings for the comparison of detection accuracy between CBCT and 2D imaging. Some of the studies had mixed results further emphasizing the need for additional research in this area particularly with sinus pathology. CBCT has shown improvement in diagnostic accuracy in several areas and it is important to use professional judgment when to order a CBCT to gain additional information.

## MANUSCRIPT

### Introduction:

Since the development of the first commercial cone beam computed tomography (CBCT) machine in the 1990s (Mozzo et al. 1998), this three-dimensional (3D) modality has been used for oral and maxillofacial imaging purposes to view the patient in multiple planes or simulate reconstructions of panoramic and cephalometric images. Despite the limited poor soft tissue contrast (Mallya & Lam 2019), CBCT shows advantages of low cost for a 3D imaging system, high accessibility and lower radiation dosage to patients when compared to multi-detector computed tomography (MDCT). An advantage of CBCT over two-dimensional (2D) imaging is that it provides a 3D look at the oral and maxillofacial region improving the ability to detect previously undiagnosed pathology (Nakata et al 2006). Over the past two decades use of CBCT machines has increased dramatically in dentistry. Application of CBCT as a standard imaging modality has been found in many different fields of dentistry including but not limited to oral and maxillofacial surgery, endodontics, implantology, orthodontics, periodontics and temporomandibular joint disorder (Almari et al. 2012).

CBCT has the capability to examine the oral and maxillofacial region with a variety of different fields-of-view (FOV). These fields may be small and encompass only a few teeth or be large and examine the maxilla and mandible as well as other surrounding structures including the skull base, cervical spine, temporomandibular joint, paranasal sinuses and airway. As a result of the high resolution and larger area covered by these scans there are a vast number of incidental findings (IF) that may be seen which are important to clinicians in the diagnosis of a disease or abnormality and findings that may not be evident on 2D imaging. A large portion of these IF are outside the maxilla and mandible and may be unfamiliar to many dental clinicians. In a systematic review, Deif et al reported “The overall frequency of IFs of the 10 selected articles ranged from 24.6 to 94.3%” (Deif et al 2019). Dental clinicians and oral and maxillofacial radiologists must carefully review a CBCT volume in its entirety to detect any significant findings within the entire volume and not just those in the area of interest (Carter et al. 2008).

Past studies have shown a difference in the detection accuracy when comparing CBCT with 2D imaging. In a 2016 systematic review by Dutra et al. it was concluded that traditional periapical radiography showed good diagnostic accuracy while CBCT showed excellent diagnostic accuracy of simulated apical periodontitis (Dutra et al. 2015). In a 2017 study by Campello et al. it was concluded that CBCT allows a higher detection accuracy of artificially induced periapical lesions than digital periapical radiography (Campello et al. 2017). In a 2017 study by Almeida et al. it was concluded that CBCT performance was not superior to that provided by conventional intraoral radiographs in the detection of interproximal bone defects (Almeida et al. 2017). In a 2012 study by Avsever et al. it was concluded that CBCT was more accurate in the detection of horizontal root fractures when compared to 2D imaging (Avsever et al. 2017).

While there have been many studies on IF in CBCT there is a paucity of studies delineating the frequency of IF per FOV from small to large. Furthermore, many common dental diseases have been explored as IF in the literature yet there is limited information on the detection of incidental findings on CBCT compared to the detection on periapical or panoramic (PAN) images. This raises an interesting question. How many CBCT IF could also be seen on 2D images?  We found no studies investigating the number of lesions identified as IF that also appear on 2D images.

The primary aim of this study is to evaluate the type and prevalence of significant IF per FOV from a CBCT unit. A second aim is to determine which of these IF are visible on periapical and/or panoramic images. The goal of this study is to help clinicians better understand which IF are more likely to appear in scans after patient evaluation with traditional 2D imaging. This will in turn improve diagnosis of disease and overall patient care.

**Materials and Methods:**

The CBCT machine utilized in this study was the Dentsply Sirona Orthophos SL 3D (Charlotte, NC) using 5x5x6cm (5cm), 8x8x8cm (8cm), and 11x11x10cm (11cm) FOV. The CBCT images were viewed with InVivo Dental software (Anatomage, Inc. San Jose, CA, USA). The research was divided into two parts. The first involved a review of CBCT scan reports, recording the type and prevalence of various significant IF for each FOV. The second involved determining if a subset of the IF visible on the CBCT scans is also visible on panoramic and intraoral radiographs. The project protocol was reviewed and approved by the Institutional Review Board (IRB) for Human Subjects Research IRB# 19-1800.

The CBCT reports of 510 consecutive patients conducted in the Oral and Maxillofacial Radiology Clinic on the Orthophos SL 3D unit from January 2017 through June 2019 were retrospectively evaluated by a single radiology resident. Once 170 reports for each FOV were collected, no more reports for that specific FOV were reviewed. Additionally, if a patient had more than one scan the additional scans were excluded. All 510 CBCT reports were written by one of three Board Certified Oral and Maxillofacial Radiologists. Diagnoses were based on radiographic appearance using classic radiographic interpretation procedures. Radiographic features used for the recording of IF were modified from the textbook: “Oral Radiology: Principles and Interpretation,” 8$^{th}$ edition by Mallya and Lam (Mallya & Lam 2019).

Supplemental clinical information was used when necessary. IF were categorized into three levels of significance using a modification from the textbook "Maxillofacial Cone Beam Computed Tomography" by Scarfe and Angelopoulos (Scarfe and Angelopoulos 2018). Level of clinical significance was classified as either low, intermediate or high. Findings with a low level of significance normally do not require clinical or radiographic follow-up. Findings with an intermediate level of significance usually require either monitoring or immediate clinical and therapeutic intervention. Findings with a high level of significance usually require immediate clinical and therapeutic intervention. Findings with an intermediate or high level of significance were considered significant IF and were included in data collection. Findings with a low level of significance and findings relating to the primary indication for the CBCT scans were excluded (Table 1). The patients' demographic data, indication for imaging and all significant IF were recorded.

The second portion of the research involved viewing a subset of IF to determine whether they were or were not also visible on panoramic and/or intraoral imaging. Dentoalveolar findings viewed included apical lesions, periodontal defects, root resorption, indirect root fractures, supernumerary teeth, tumor/cyst/fibro-osseous lesions, dens invaginatus, and fistula. Paranasal sinus findings viewed included sinusitis, antral polyps, antroliths and mucus retention pseudocysts. Neck soft tissue findings viewed included carotid atheroma and sialoliths. Some IF were combined into groups. Apical lesions is a combined group consisting of periapical rarefying osteitis and sclerosing osteitis. When both were the result of a single tooth they were counted as one finding. Periodontal defects is a combined group of vertical periodontal defects and defects involving the furcation. Root resorption is a combined group for both internal and external root resorption. Tumor/cyst/fibro-osseous is a combined group for all benign tumors, malignant tumors, cysts, and fibro-osseous lesions. Sinusitis is a combined group for acute sinusitis, chronic sinusitis, blocked ostiomeatal complex, and total opacification. Antrolith is a combined group for both antrolith and dystrophic sinus calcifications.

Patient radiographic records were reviewed by a single radiology resident to determine if panoramic or intraoral imaging was available. Radiographs that were taken within one year of the CBCT scan, and completely captured the area of interest were included. Radiographic images that were taken more than one year from the CBCT acquisition, did not capture the area of interest fully, or images with quality that was determined non-diagnostic were excluded.

The panoramic and intraoral radiographs were reviewed independently by two board certified oral and maxillofacial radiologists. An answer of yes, no or unsure was given to each radiograph to determine whether or not an IF was visible, was not visible, or if there is uncertainty. The Delphi method was used to arrive at a consensus agreement (Dalkey & Helmer 1963). The data was evaluated using simple descriptive statistics to illustrate the percentage of findings that were categorized as yes, no and unsure.

**Results:**

The mean age for all patients was 54.3 years (range 8-91 years). The mean age for the 5cm, 8cm and 11cm FOV was 51.8, 56.5, and 54.6 years respectively. The reason for the CBCT scans included implant treatment planning, endodontic evaluation, evaluation of impacted teeth, surgical planning and pathosis. The predominant reason for the 5cm FOV was endodontic evaluation (78.8%) followed by impaction (4.1%), surgical planning (4.1%) and implant planning (2.4%). The predominant reason for the 8cm FOV was implant planning (83.5%) followed by impaction (6.5%), surgical planning (3.5%), pathosis (3.5%) and endodontic evaluation (2.9%). The predominant reason for the 11cm FOV was implant planning (78.8%)

followed by impaction (6.5%), surgical planning (5.9%), pathosis (5.3%) and endodontic evaluation (3.5%).

For all combined FOV, 677 significant IF were discovered on 302 (59.2%) of the 510 CBCT scans reviewed for an overall 1.33 findings per scan rate (677 divided by 510). If one examines only the scans with positive significant findings, the findings per scan rate is 2.24 findings per scan (677 divided 302). 208 (40.8%) of the scans showed no significant IF. For the 5cm FOV, 101 significant IF were discovered on 68 (40%) of the 170 CBCT scans reviewed for an overall 0.59 findings per scan rate (101 divided by 170). If one examines only the scans with positive significant findings, the findings per scan rate is 1.49 findings per scan (101 divided 68). 102 (60%) of the scans showed no significant IF. For the 8cm FOV, 279 significant IF were discovered on 114 (67.1%) of the 170 CBCT scans reviewed for an overall 1.62 findings per scan rate (275 divided by 170). If one examines only the scans with positive significant findings, the findings per scan rate is 2.41 findings per scan (275 divided 114). 56 (32.9%) of the scans showed no significant IF. For the 11cm FOV 297 significant IF were discovered on 120 (70.6%) of the 170 CBCT scans reviewed for an overall 1.75 findings per scan rate (297 divided by 170). If one examines only the scans with positive significant findings, the findings per scan rate is 2.48 findings per scan (297 divided 120). 50 (29.4%) of the scans showed no significant IF.

For all combined FOV there were 457 (57.5%) dentoalveolar, 169 (25%) paranasal sinus, 36 (5.3%) neck soft tissue, 7 (1%) pharyngeal airway, and 2 (0.3%) other significant IF. A summary of the IF frequency distribution by location and FOV is summarized in (Table 2).

For the second portion of the study a subset of incidental findings was observed on either intraoral periapical (PA) or panoramic (PAN) imaging. An observation of yes, no or unsure was given to each incidental finding. Observational data for the subset of significant IF by two oral and maxillofacial radiologists is summarized in (Table 3).

**Discussion:**

CBCT is a useful imaging tool that can provide diagnostic information about a variety of findings in a large area of the oral and maxillofacial region. Many findings that can be seen do not relate to the area of interest. Additionally, a portion of these findings are outside the dentoalveolar region and may be unfamiliar to many dentists. The number of IF in previous studies ranged from 24.6%-94.3% (Deif et al. 2019) All of these studies used a large FOV. This study separated the findings based on the FOV. Previous studies classified all findings outside the area of interest as IF which led to the question, how many of the IF found on CBCT scans are truly incidental? That is to say, which findings could not be seen on 2D imaging already? Even if the findings are seen in 2D, 3D often reveals greater extent of the lesion. The significance of IF may be low requiring no follow up, intermediate requiring monitoring or intervention, or high requiring immediate intervention. This study recorded IF of intermediate or high significance from 510 CBCT reports using three different FOV and retrospectively looked at 2D imaging to determine if they were or were not visible.

In this study, the mean age and range of ages was similar for all three FOV. There was however a difference in the predominant reason for the scan. For the 5cm FOV the predominant reason for the scan was endodontic evaluation. For the 8cm and 11cm FOV the predominant reason for the scan was implant planning.

In the 510 reports, a total of 302 (59.2%) contained 677 significant IF for an average of 1.33 findings per scan. For the 5cm FOV, a total of 68 (40%) reports contained 101 significant IF for an average of 0.59 findings per scan. In the 8cm FOV, a total of 114 (67%) reports contained

279 significant IF for an average of 1.64 findings per scan. In the 11cm FOV, a total of 120 (70.6%) reports contained 297 significant IF for an average of 1.75 findings per scan. With an increase in the FOV size, there was also an increase in the total number of significant IF.

The dentoalveolar region represented the most frequent location for significant IF. Overall there were 457 in total with a distribution by FOV of 69 (5cm), 199 (8cm), and 190 (11cm). The most frequent finding was apical lesions (150), followed by periodontal defects (125), root fragments (47), impaction (40), hypercementosis (21), indirect root fracture (16), external root resorption (15), fibro-osseous lesions (14), dental cyst/tumors (8), enamel pearl (5), dens invaginatus (3), osteopenia (3), internal root resorption (3), and fusion (1). The 5cm FOV had fewer total IF when compared to either the 8cm or 11cm FOV. The 5cm FOV only captures a few teeth in a single quadrant. The 8cm and 11cm FOV were similar when compared because they both capture the maxilla and mandible entirely.

The paranasal sinus region represented the second most frequent location for significant IF. Overall there were 169 in total with a distribution by FOV of 31 (5cm), 72 (8cm), 66 (11cm). The most frequent finding was chronic sinusitis (64), followed by antroliths/calcification (28), antral polyps (28), mucus retention pseudocyst (24), acute sinusitis (11), antro-oral fistula (6), total opacification (4), and blocked osteomeatal complex (2). The 5cm FOV had approximately half as many findings when compared to either the 8cm or 11cm FOV. The 5cm FOV captures the sinus only when maxillary molars are the area of interest. When mandibular teeth or the anterior maxilla is imaged, the sinuses cannot be visualized. The 8cm and 11cm FOV had a similar total number of IF. The 8cm usually captured most of the sinus while the 11cm FOV captured the entire sinus. The 11cm FOV had 8 fewer findings, but this is likely due to statistical variation.

The neck soft tissue region represented the third most frequent location for significant IF. Overall there were 36 in total with a distribution by FOV of 1 (5cm), 2 (8cm) and 33 (11cm). The most frequent finding was extracranial calcified carotid artery atheromas (25), sialolith (8), and facial calcifications (2). Nearly all of the findings in this region were found in the 11cm FOV. The 8cm FOV only captures a small portion of the next soft tissue. The 5cm FOV only captures a small portion of the neck soft tissue and only when the mandible is being imaged. There were no extracranial calcified carotid artery atheromas seen in the 5cm FOV and only 1 in the 8cm FOV with 24 being seen in the 11cm FOV. The most common location for these calcifications is at the level of the cervical spine C3 and C4 which is not captured in the 5cm and 8cm FOV. However, this is almost always captured in the 11cm FOV. One sialolith was found in both the 5cm and 8cm FOV with 7 in the 11cm FOV. No facial artery calcifications were seen on the 5cm and 8cm FOV with 2 in the 11cm FOV.

The pharyngeal airway region represented the fourth most frequent location for significant IF. Overall there were 7 in total with a distribution by FOV of 0 (5cm), 0 (8cm), and 7 (11cm). The most frequent finding was tonsillar hyperplasia (4) followed by soft tissue mass/tumor (3). The 5cm and 8cm FOV had no findings in this region because they never capture this area.

The final category classified as other had 2 findings. In the 5cm FOV there was a patient with a history of a nasopalatine duct cyst that was removed and did not show signs of healing. In the 11cm FOV a patient had soft tissue inflammation with signs of sialadenitis.

Previous studies have shown a variation in detection accuracy when comparing CBCT with intraoral radiography. In our literature search, we found no studies investigating the number of lesions identified as IF that also appear on 2D images. A subset of IF were combined into several groups for review on either a PA images only, PAN images only or both. This study found that many of the IF that were detected on CBCT were not visible on PA or PAN images. Dentoalveolar findings were the most common and generally had the highest positive detection frequency on 2D imaging. Paranasal sinus findings were the second most common, but had the lowest positive detection frequency on 2D imaging. The neck soft tissue findings were the least common and positive detection frequency on 2D images was between the dentoalveolar and paranasal sinus.

Apical lesions is a combined group of periapical rarefying osteitis and periapical sclerosing osteitis. If a single tooth exhibited features of both, they were counted as a single finding. Of the 78 PA images reviewed 26 (33.3%) were not visible or there was uncertainty (Fig 1). In a systematic review by Dutra et al. it was found that sensitivity and specificity for the detection of artificial apical periodontitis with digital projection radiography was 0.56 and 0.78. For CBCT imaging the sensitivity and specificity was 0.95 and 0.88. Diagnostic accuracy improved on PA imaging when lesions were within cortical bone as opposed to trabecular bone alone. Additionally larger lesions were also detected at a higher rate (Dutra et al. 2015). This study found a similar trend. There was no apparent difference in detection frequency when comparing the time between 2D and CBCT imaging or the location of the lesion.

Periodontal defects is a combined group of vertical periodontal defects and furcation defects. If a single tooth exhibited features of both, they were counted as a single finding. Of the 72 PA images reviewed, 26 (36.1%) were not visible or there was uncertainty. A study by Bayat et al. concluded that “CBCT was superior to digital intraoral radiographs in the detection of Grade I furcation involvements, three-wall defects, dehiscence and fenestrations”. Additionally, “No significant difference was noted between CBCT and digital radiography for the detection of

Grades II and III furcation involvements, one-wall, two-wall and trough-like defects (Bayat et al.). In this study we found that smaller furcation defects were more difficult to detect on 2D imaging. This is likely because the Xray beam angulation is not always perpendicular to the defect. Furcation defects that had overlapping structures such as the palatal root of a maxillary molar and vertical defects that were on either the facial or lingual surface were also more difficult to detect.

Root resorption was a combined group of external and internal root resorption. When a single tooth exhibited features of both, they were counted as a single finding. Apical root resorption is sometimes considered external root resorption, but for the purposes of this study was not included. Of the 6 PA images reviewed, 4 (66%) were not visible or there was uncertainty. A study by Durack et al. concluded that limitations by intraoral radiographs can be overcome by CBCT imaging. Resorption that was small or located on the buccal or lingual surface was more difficult to detect (Durack et al. 2010). In this study smaller lesions were less likely to be detected on 2D imaging.

Vertical root fractures of endodontically treated teeth can be difficult if not impossible to see on both CBCT and 2D imaging. When an endodontically treated tooth has an apical lesion extending up the root surface with a “J” shape, it is considered to be suggestive of and was counted as an indirect root fracture. Of the 10 PA images reviewed, 8 (80%) were not visible. When lesions were smaller or on the buccal and lingual surface of the root, they were less likely to be detected in 2D imaging.

Supernumerary teeth were reviewed only on panoramic imaging. Of the 4 panoramic images reviewed, 2 (50%) were not visible. The two that were visible were on the same patient and located at site #20 and #21. Both teeth were within the focal trough. The two that were not visible were also on a different patient and were smaller with overlapping structures likely impeding visualization.

Dental cysts, benign tumors, and fibro-osseous conditions were combined into a single group. Of the 7 PA images reviewed, 4 (57.1%) were not visible or there was uncertainty. Of the 3 Pan images reviewed, 2 (66.6%) were not visible or there was uncertainty. One finding was a hyperplastic follicle with internal calcification and a biopsy recommendation. The internal calcifications could not be seen on PAN imaging. One finding was a residual cyst in the maxilla. The time between imaging was 202 days so the cyst may not have been present at the time the PA image was taken. The remainder of the findings were periapical cemento-osseous dysplasia. Detection was higher on PA imaging if the internal radiolucent area also contained calcifications. If the calcifications were not present detection was lower.

Only 1 finding of dens invaginatus was reviewed and it was visible in the PA image.

Sinusitis was a combined group of acute sinusitis, chronic sinusitis, total opacification, and blocked osteomeatal complex. Of the 35 PA images reviewed, 29 (82.9%) were not visible or there was uncertainty. Of the 22 PAN images reviewed, 17 (77.3%) were not visible or there was uncertainty. Sinusitis had a large portion that were not visible. Most of the scans were taken a month to a year apart from the 2D imaging and the sinusitis may not have been present at all. However, even if we look only at images taken within one month there is only a small increase in the frequency detected on PA and PAN images. The degree of thickness may play a role. There were four cases of total sinus opacification. One was taken within 12 days, but it was not visible on PA imaging.

A finding of radiographic polypoid mucosal thickening, was recorded as antral polyps. Of the 9 PAN images reviewed, 9 (100%) were not visible. Antral polyps are generally small and often outside the focal trough which is likely why none were detected. Additionally most imaging was taken more than 4 months from the 2D imaging. The polyps may have been smaller or not present at all at the time of CBCT imaging.

Antrolith is a combined category of any radiographic calcification within the sinus. Of the 12 PA images reviewed, 10 (83.3%) were not visible. Of the 6 PAN images reviewed, 5 (83.3%) were not visible. The large number of findings that were not visible is likely due to them being small or outside the focal trough.

Mucus retention pseudocyst is defined radiographically as a dome shaped soft tissue dense entity located on the floor of the sinus. Of the 9 PA images reviewed, 8 (88.9%) were not visible. Of the 5 PAN images reviewed, 3 (60%) were not visible. Mucus retention pseudocysts tend to resolve on their own and may not have been present at the time 2D imaging was acquired. There were three cases within a month and two were visible while one was not. There was a single case with imaging 6 months apart and it was visible. The remainder were taken more than a month apart and were not visible. The small number detected on 2D imaging is likely a combination of time between the scan and the size of the entity.

Only 1 finding of a fistula was reviewed and it was not visible in the PA image. This was most likely not detected due to the size of the fistula. On PAN imaging the sinus border appears intact. There was however a slight reduction in density where the fistula was located.

Carotid atheroma is a group that consists of only external carotid artery calcifications at the level of C3 and C4 in the neck soft tissues. Of the 9 PAN images reviewed, 5 (55.6%) were not visible. This is likely due to the finding either being too small or too low on the panoramic image. All 5 images where the atheromas were not visible were a results of panoramic positioning errors. 4 patients had their chin tilted upward. One was positioned too far posteriorly. Detection rates can be increased with proper patient positioning.

Sialoliths were reviewed only on panoramic images. Of the 4 PAN images reviewed, 3 (75%) were not visible. Each of the 3 that were not visible were small in size and overlapped the mandible which likely reduced detectability.

This study shows that in a typical clinical setting there are many significant findings detected on CBCT that are not visible on 2D imaging which are relevant to a dental clinician. Even if a patient already has comprehensive intraoral and panoramic imaging, it is still important to fully evaluate the entire CBCT volume for the presence of disease. A dental clinician that orders a CBCT is responsible for interpreting the entire volume including areas outside the dentoalveolar region. If a dental clinician is unwilling to accept this responsibility then the CBCT volume should be referred to an Oral and Maxillofacial Radiologist for interpretation and a comprehensive report (Carter et al).

A limitation of this study was the low number of findings in several of the categories reviewed on 2D imaging. This low number likely skews some of the frequency of detection numbers in one direction which may not representative of a larger sample. With the exception of apical lesions, periodontal defects, and sinusitis, all other categories had 12 or fewer images reviewed with the lowest being one. Future research in this area could focus on specific findings in order to better quantize the frequency of these findings with a larger pool.

**Conclusion:**

This study confirms that the frequency of significant IF on CBCT that do not relate to the area of interest is high. Decreasing the FOV will reduce the frequency of IF. However, there is still a large number of dentoalveolar and paranasal sinus findings that will remain present even on small volume CBCT scans. This study also confirmed that a portion of the findings detected on CBCT images were not visible on 2D imaging. Therefore, it is of tremendous importance no matter the age, reason for the scan, FOV, or previous imaging that a dental clinician or oral and maxillofacial radiologist review a CBCT volume in its entirety and with great care. After a review of the CBCT volume, it is also important to go back and compare any findings with 2D images. Careful review of all patient imaging is necessary in order to avoid missing any important disease processes and improve patient care.

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# TABLES AND FIGURES

**(Table 1) Summary of incidental findings separated by level of significance (low, intermediate and high):**

| # | Category | Incidental Finding | |
|---|---|---|---|
| **1** | **Dentoalveolar (High and Intermediate)** | Periapical Rarefying Osteitis | Dentinogenesis Imperfecta |
| | | Sclerosing Osteitis | Amelogenesis Imperfecta |
| | | External Root Resorption | Enamel Pearl |
| | | Internal Root Resorption | Impaction |
| | | Hypercementosis | Root Fragments |
| | | Dense Invaginatus | Cleft Palate |
| | | Supernumerary Teeth | Osteopenia |
| | | Microdontia | Indirect Root Fracture |
| | | Macrodontia | Fibro-osseous Lesions |
| | | Gemination | Cysts |
| | | Fusion | Benign Tumors |
| | | Taurodontism | Malignant Tumors |
| | | Periodontal Defect | Osteomyelitis/Osteonecrosis |
| | | Dentin Dysplasia | |
| **1** | **Dentoalveolar (Low)** | Dense Bone Island | Dental Caries |
| | | Torus/Exostosis | |
| **2** | **Paranasal Sinuses (High and Intermediate)** | Acute Sinusitis | Foreign Body |
| | | Chronic Sinusitis | Antrolith/Antral Calcifications |
| | | Mucus Retention Pseudocyst | Air-Fluid Level |
| | | Blocked Ostiomeatal Complex | Antral Polyps |
| | | Total Opacifications | Accessary Ostia |
| | | Antro-oral Fistula | Soft Tissue Mass/Tumor |
| **2** | **Paranasal Sinuses (Low)** | Mucosal thickening | Septations |
| | | Hypoplasia | Pneumatization |
| **3** | **Nasal Fossa (High and Intermediate)** | Concha Hypertrophy | Soft Tissue Mass/Tumor |
| | | Rhinitis/Nasal Polyposis | |
| **3** | **Nasal Fossa (Low)** | Deviated Nasal Septum | Concha Bullosa |
| **4** | **Pharyngeal Airway (High and Intermediate)** | Tonsillar Hypertrophy | Soft Tissue Mass/Tumor |
| | | Airway Obstruction | |
| **4** | **Pharyngeal Airway (Low)** | Tonsilloliths | |
| **5** | **TMJ (High and Intermediate)** | Degenerative Joint Disease | Condylar Hyperplasia |
| | | Coronoid Hyperplasia | Condylar Hypoplasia |
| **5** | **TMJ (Low)** | Osteoarthritic Changes | Bifid Condyle |
| | | Remodeling | |
| **6** | **Skull Base/Brain (High and Intermediate)** | Irregular Pineal Gland Calcifications | Non-Calcified Carotid Artery Atheroma |
| | | Intracranial Calcified Carotid Artery Atheroma | Enlarged Sella Turcica |
| **6** | **Skull Base/Brain (Low)** | Pineal Gland Calcification | |
| **7** | **Temporal Bone (High and Intermediate)** | Opacification of Middle Ear | Cholesteatoma |
| | | Opacification of Mastoid Air Cells | |
| **8** | **Cervical Spine (High and Intermediate)** | Herniation of an Invertebral Disc | Tumor Like Lesions |
| **8** | **Cervical Spine (Low)** | Osteoarthritic Changes | |
| **9** | **Neck Soft Tissue (High and Intermediate)** | Foreign Body | Extra Cranial Calcified Carotid Artery Atheroma |
| | | Sialolith | Soft Tissue Mass/Tumor |
| **9** | **Neck Soft Tissue (Low)** | Stylohyoid Ligament Calcification | Tritecious Cartilage Calcifications |

| | | | |
|---|---|---|---|
| | | Thyroid Cartilage Calcifications | |
| **10** | **Other (High and Intermediate)** | Proptosis | |

**(Table 2) IF Frequency Distributions 5x5x6, 8x8x8, 11x11x10**

| # | Category | Incidental Finding | 5x5x6 No. of IFs (%) | 8x8x8 No. of IFs (%) | 11x11x10 No. of IFs (%) |
|---|---|---|---|---|---|
| **1** | **Dentoalveolar** | **Total IFs** | 68 (67.3%) | 199 (72.9%) | 190 (64%) |
| | | Periodontal Defect | 25 | 67 | 33 |
| | | Apical Lesion | 13 | 66 | 71 |
| | | Hypercementosis | 9 | 3 | 9 |
| | | Impaction | 7 | 12 | 21 |
| | | Root Fragments | 5 | 15 | 27 |
| | | External Root Resorption | 3 | 4 | 8 |
| | | Dens Invaginatus | 2 | 1 | 0 |
| | | Dental Cyst/Benign Tumor | 1 | 3 | 4 |
| | | Enamel Pearl | 1 | 2 | 2 |
| | | Indirect Root Fracture | 1 | 8 | 7 |
| | | Osteopoenia | 1 | 1 | 1 |
| | | Fibro-osseous Lesions | 0 | 9 | 5 |
| | | Internal Root Resorption | 0 | 2 | 1 |
| | | Fusion | 0 | 0 | 1 |
| **2** | **Paranasal Sinuses** | **Total IFs** | 31 (30.7%) | 72 (26.4%) | 66 (22.2%) |
| | | Chronic Sinusitis | 9 | 28 | 27 |
| | | Antroliths/Calcifications | 8 | 11 | 9 |
| | | Antral Polyps | 5 | 11 | 12 |
| | | Mucus Retention Pseudocyst | 4 | 11 | 9 |
| | | Antro-Oral Fistula | 2 | 4 | 0 |
| | | Acute Sinusitis | 1 | 5 | 5 |
| | | Blocked Ostiomeatal Complex | 1 | 1 | 2 |
| | | Total Opacification | 1 | 1 | 2 |
| **4** | **Pharyngeal Airway** | **Total IFs** | 0 (0%) | 0 (0%) | 7 (2.4%) |
| | | Soft Tissue Mass/Tumor | 0 | 0 | 3 |
| | | Tonsillar Hypertrophy | 0 | 0 | 4 |
| **9** | **Neck Soft Tissue** | **Total IFs** | 1 (1%) | 2 (0.7%) | 33 (11.1%) |
| | | Sialolith | 1 | 1 | 7 |
| | | Extra Cranial Calcified Carotid Artery Atheroma | 0 | 1 | 24 |
| | | Facial Calcifications | 0 | 0 | 2 |
| **10** | **Other** | **Total IFs** | 1 (1%) | 0 (0%) | 1 (0.3%) |
| | | Non-Healing Nasopalatine Duct Cyst | 1 | 0 | 0 |
| | | Sialadenitis | 0 | 0 | 1 |

**(Table 3) Summary of Observations for Intraoral and Panoramic Imaging**

| Category | Incidental Finding | Image Type | Total Observed | Total seen 2D (%) | Total not seen 2D (%) | Total Unsure (%) |
|---|---|---|---|---|---|---|
| **Dentoalveolar** | Apical Lesions | PA | 78 | 52 (66.7%) | 13 (16.7%) | 13 (16.7%) |
| | Periodontal Defects | PA | 72 | 46 (63.9%) | 19 (26.4%) | 7 (9.7%) |
| | Root Resorption | PA | 6 | 2 (33.3%) | 2 (33.3%) | 2 (33.3%) |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Indirect Root Fracture | PA | 10 | 2 (20%) | 3 (30%) | 5 (50%) |
| | Supernumerary | PAN | 4 | 2 (50%) | 2 (50%) | 0 (0%) |
| | Tumor/Cyst/Fibro-osseous | PA | 7 | 3 (42.9%) | 4 (57.1%) | 0 (0%) |
| | Tumor/ Cyst/ Fibro-osseous | PAN | 3 | 1 (33.3%) | 1 (33.3%) | 1 (33.3%) |
| | Dens Invaginatus | PA | 1 | 1 (100%) | 0 (0%) | 0 (0%) |
| **Paranasal Sinuses** | Sinusitis | PA | 35 | 6 (17.1%) | 14 (40%) | 15 (42.9%) |
| | Sinusitis | PAN | 22 | 5 (22.7%) | 10 (45.5%) | 7 (31.8%) |
| | Antral Polyp | PAN | 9 | 0 (0%) | 9 (100%) | 0 (0%) |
| | Antrolith | PA | 12 | 2 (16.7%) | 10 (83.3%) | 0 (0%) |
| | Antrolith | PAN | 6 | 1 (16.7%) | 5 (83.3%) | 0 (0%) |
| | Mucus Retention Pseudocyst | PA | 9 | 1 (11.1%) | 8 (88.9%) | 0 (0%) |
| | Mucus Retention Pseudocyst | PAN | 5 | 2 (40%) | 3 (60%) | 0 (0%) |
| | Fistula | PA | 1 | 0 (0%) | 1 (100%) | 0 (0%) |
| **Neck Soft Tissue** | Carotid Atheroma | PAN | 9 | 4 (44.4%) | 5 (55.6%) | 0 (0%) |
| | Sialolith | PAN | 4 | 1 (25%) | 3 (75%) | 0 (0%) |

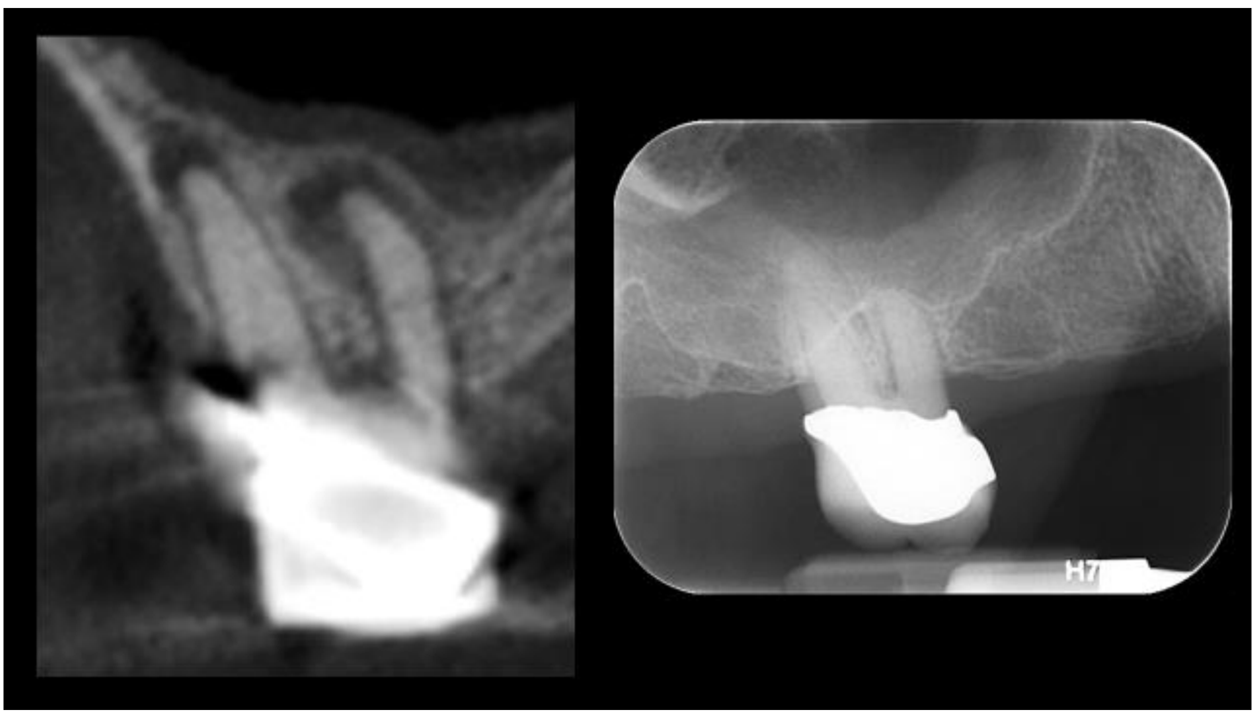


Fig 1. Apical lesion #3 CBCT (left) not visible on PA (right)

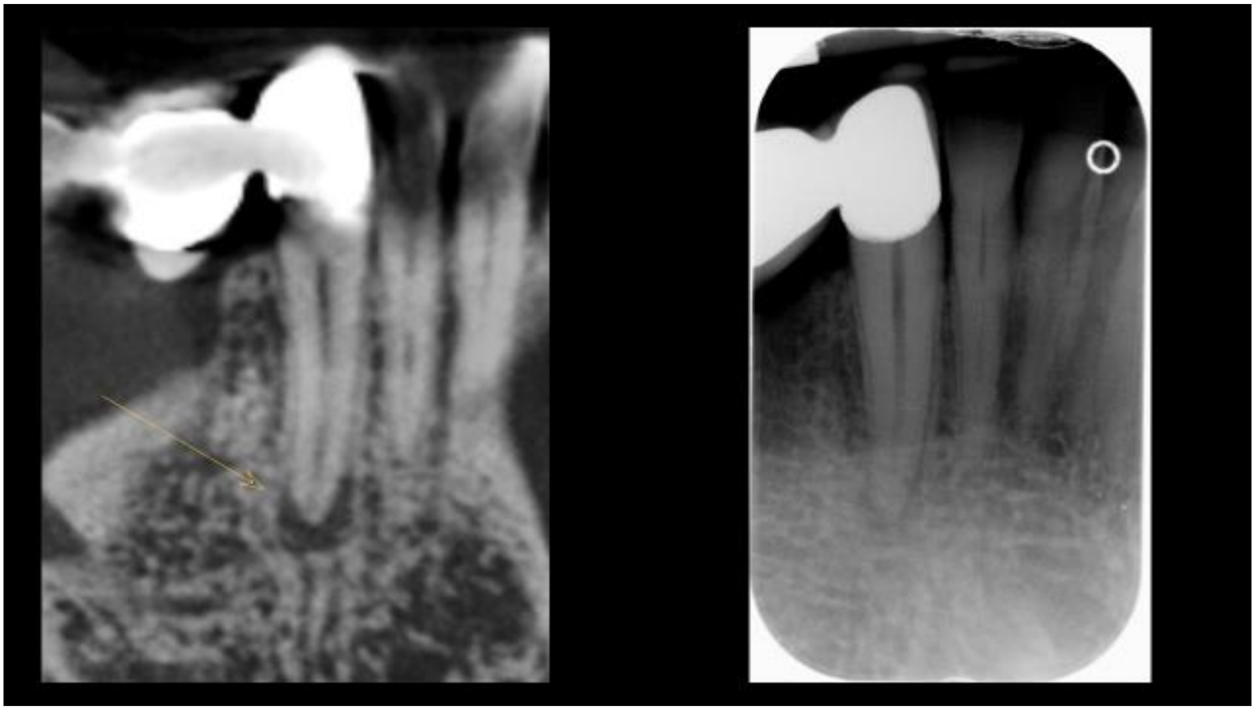
Fig 2. Apical lesion #27 CBCT (right) visible on PA (right)

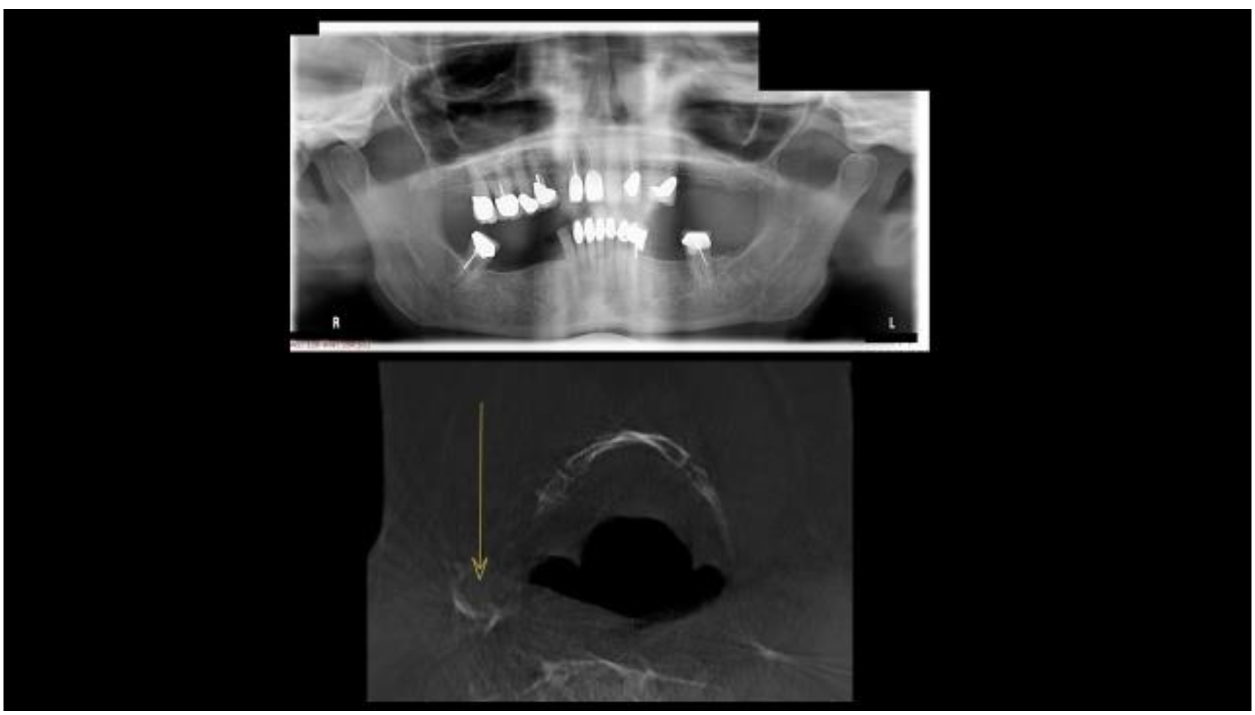

Fig 3. Carotid Atheroma CBCT (bottom) not visible on PAN (top)

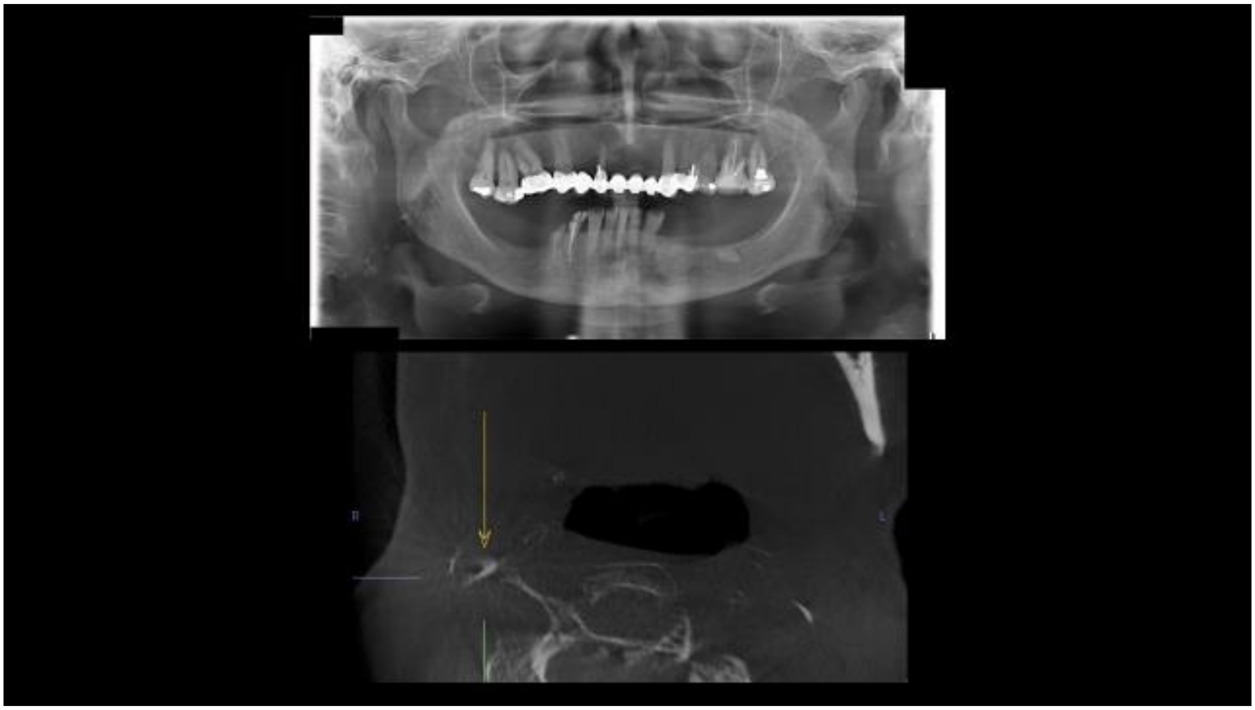

Fig 4. Carotid Atheroma CBCT (bottom) visible on PAN (top)

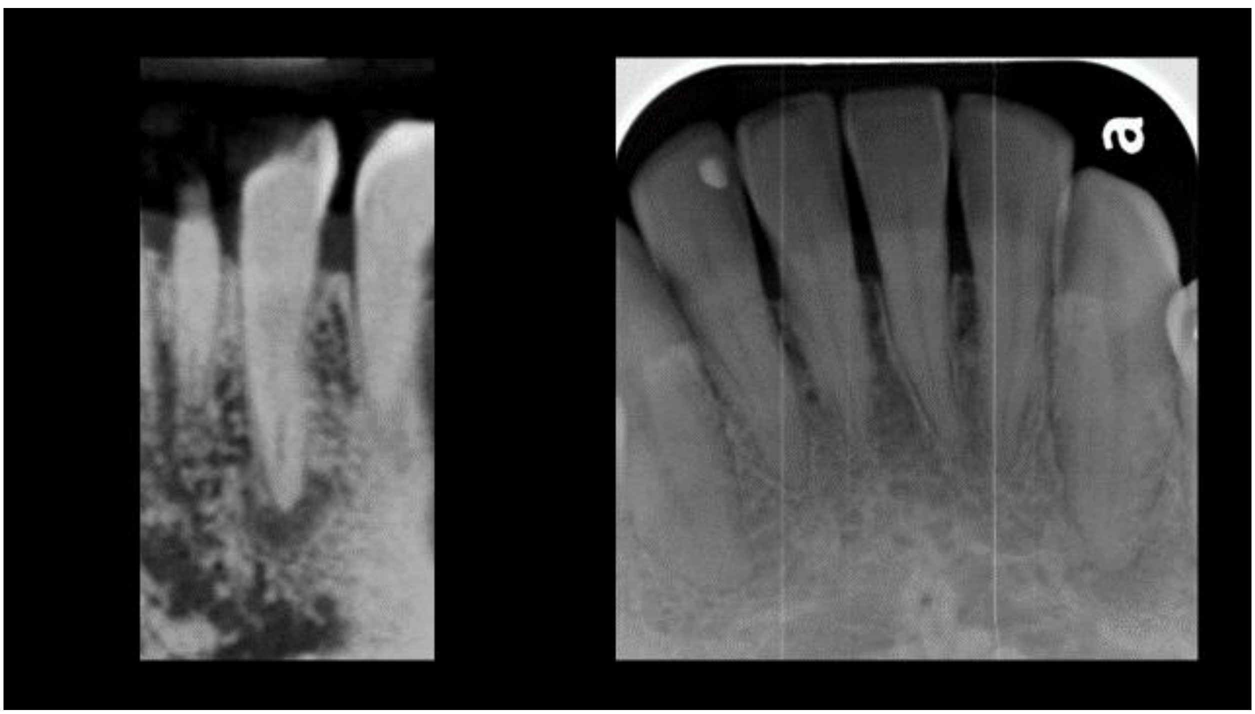


Fig 5. Periapical Cemento Osseous Dysplasia CBCT (left) not visible on PA (right)

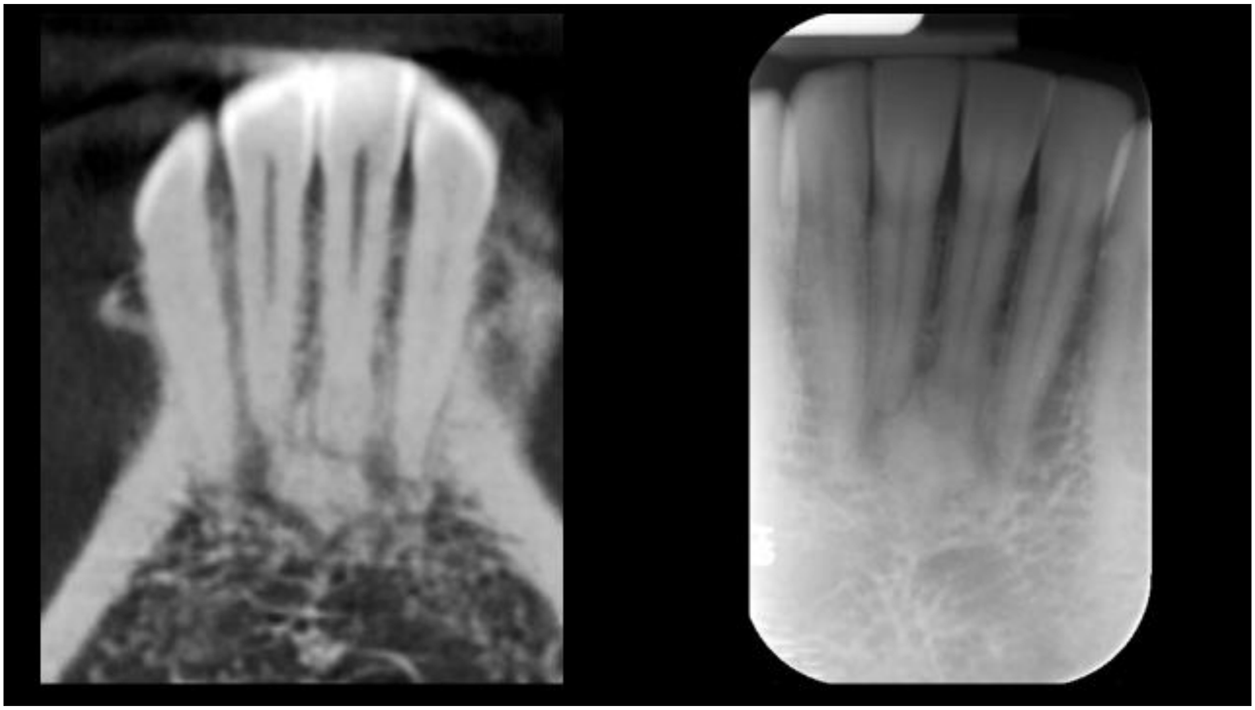

Fig 6. Periapical Cemento Osseous Dysplasia CBCT (left) visible on PA (right)

Fig 7. Residual Cyst CBCT (left) not visible on PA (right)

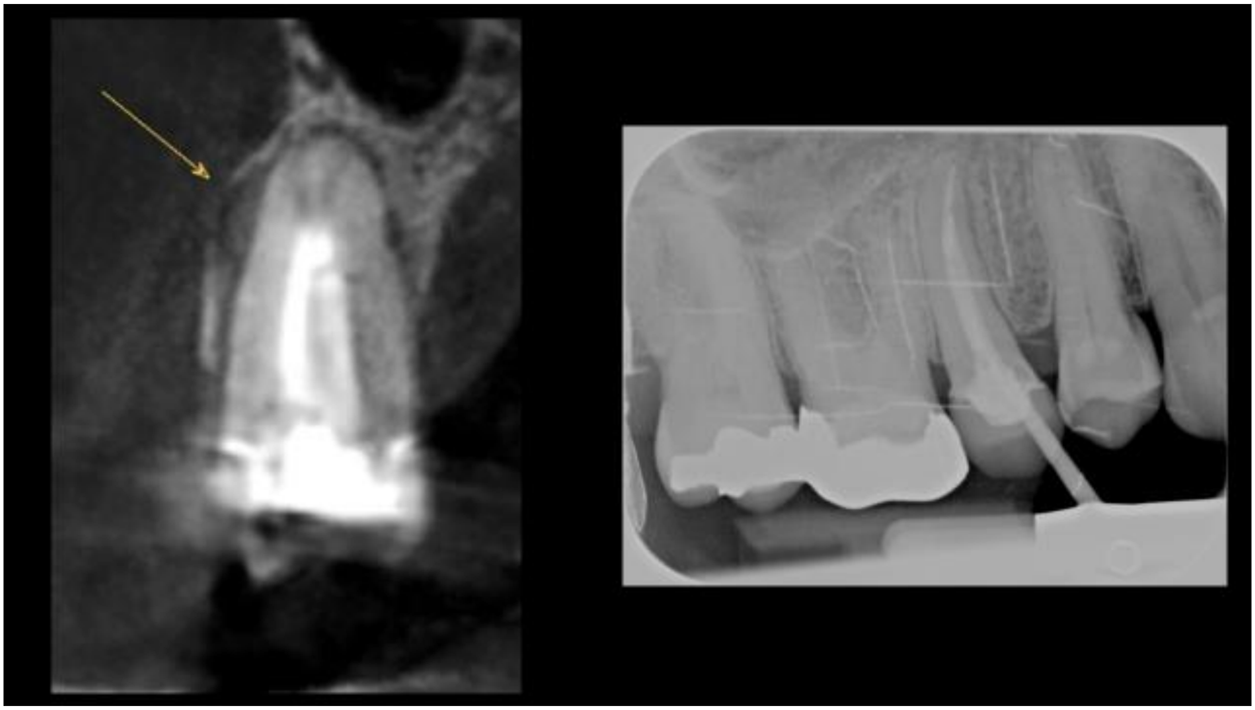

Fig 8. Indirect root fracture #4 CBCT (left) not visible on PA (right)

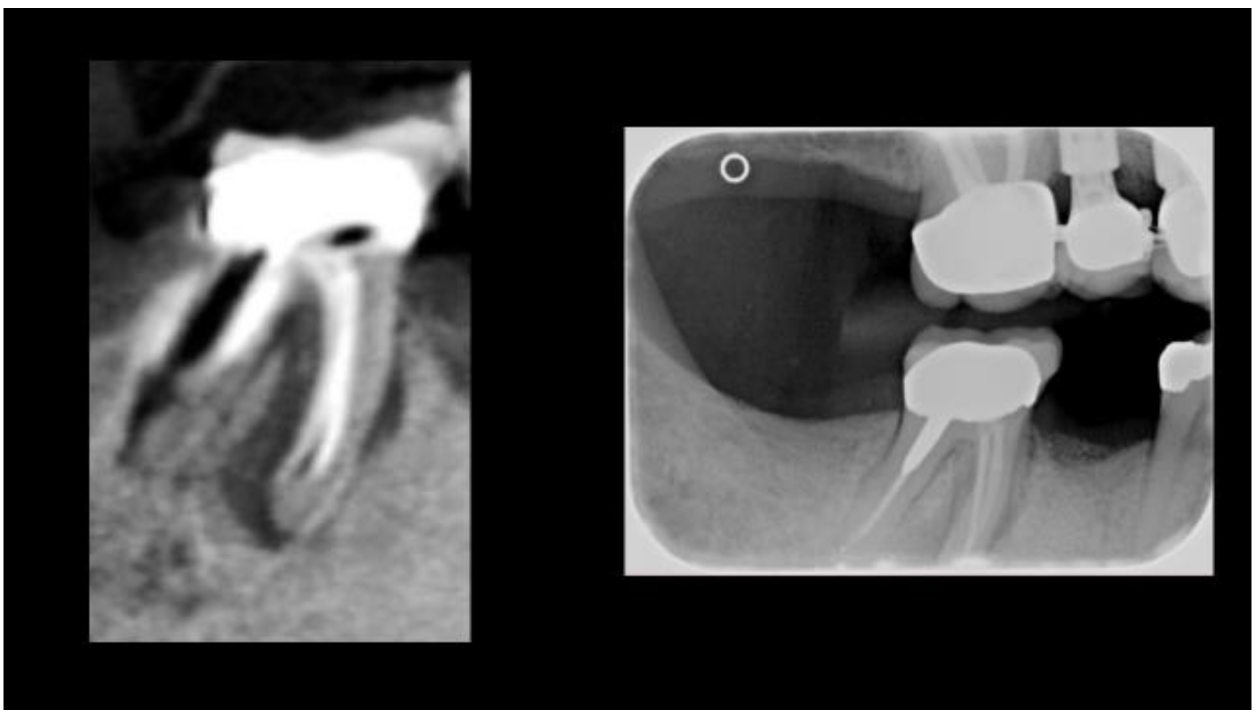

Fig 9. Indirect root fracture #30 CBCT (left) visible on PA (right)

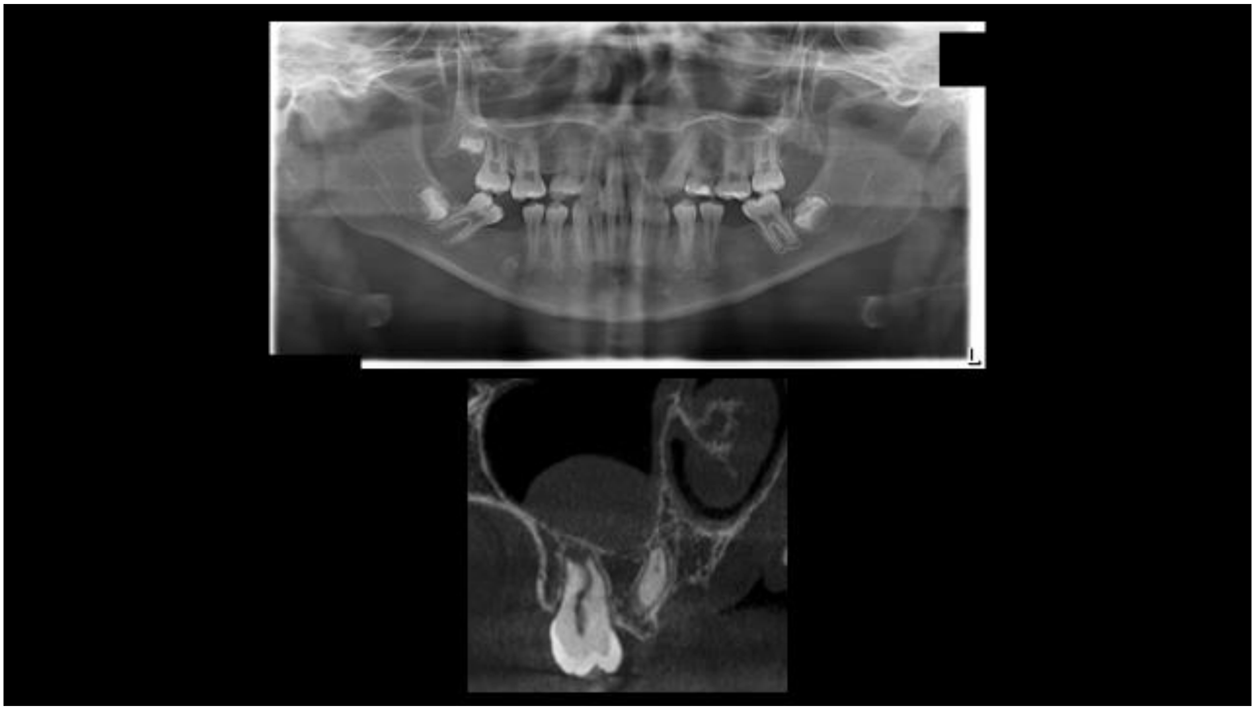

Fig 10. Mucus retention pseudocyst CBCT (bottom) not visible on PAN (right)

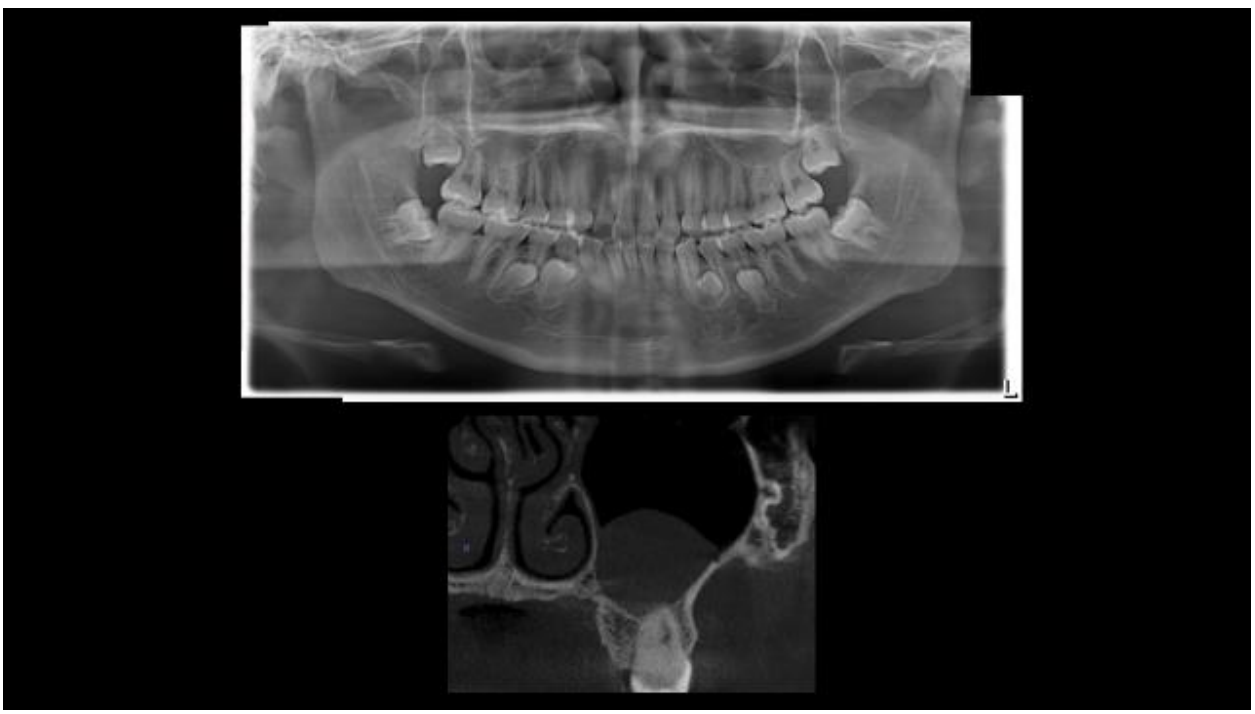

Fig 11. Mucus retention pseudocyst CBCT (bottom) visible on PAN (top)

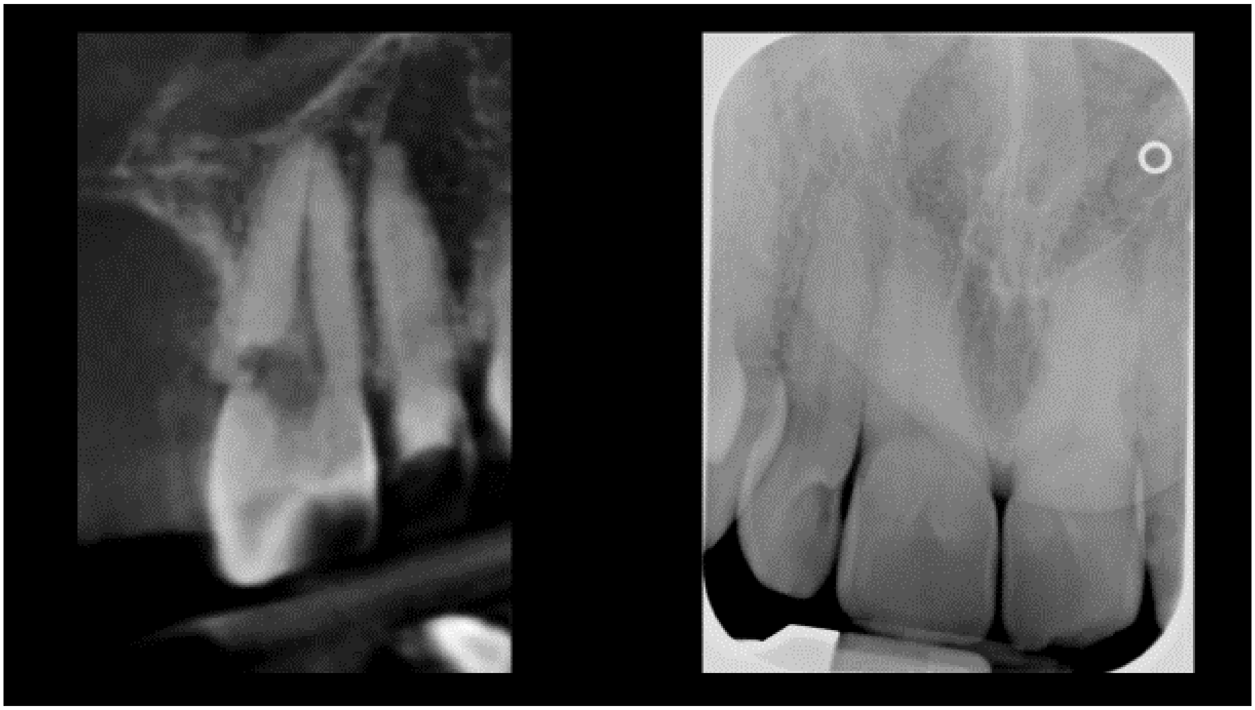
Fig 12. Internal root resorption #9 CBCT (left) not visible on PA (right)

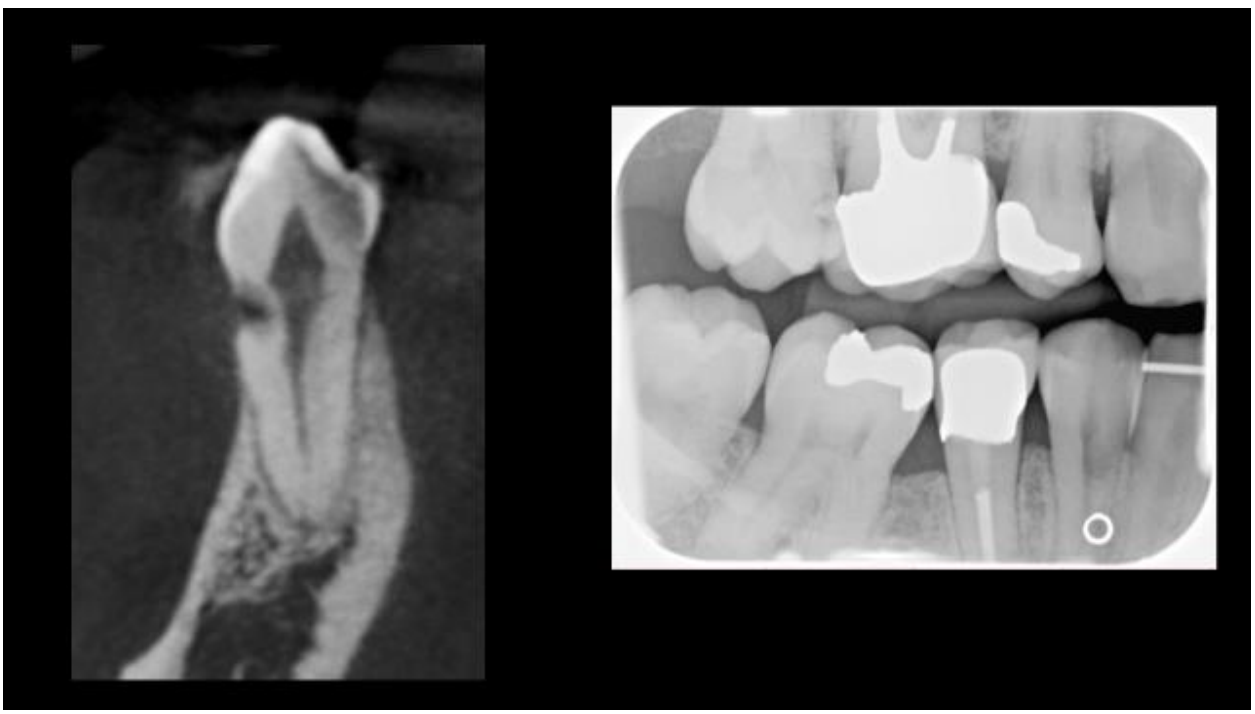
Fig 13. Internal root resorption #28 CBCT (left) visible on PA (right)

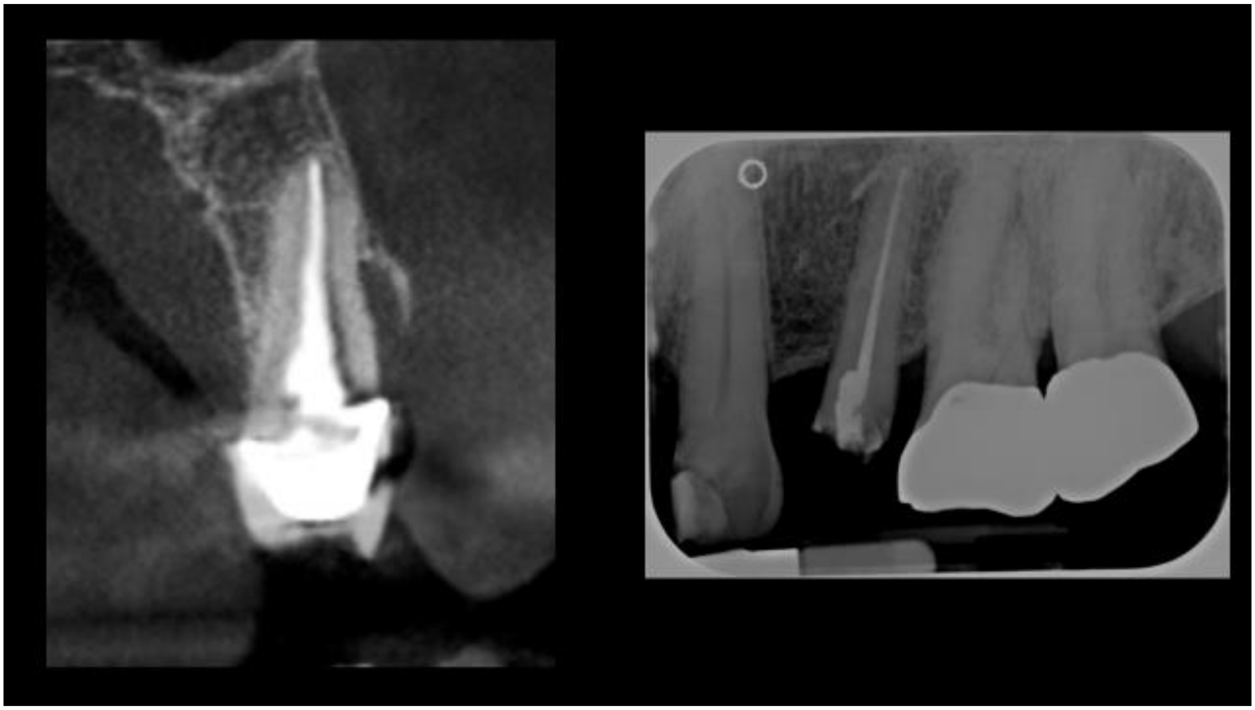
Fig 14. Buccal vertical defect #13 CBCT (left) not visible on PA (right)

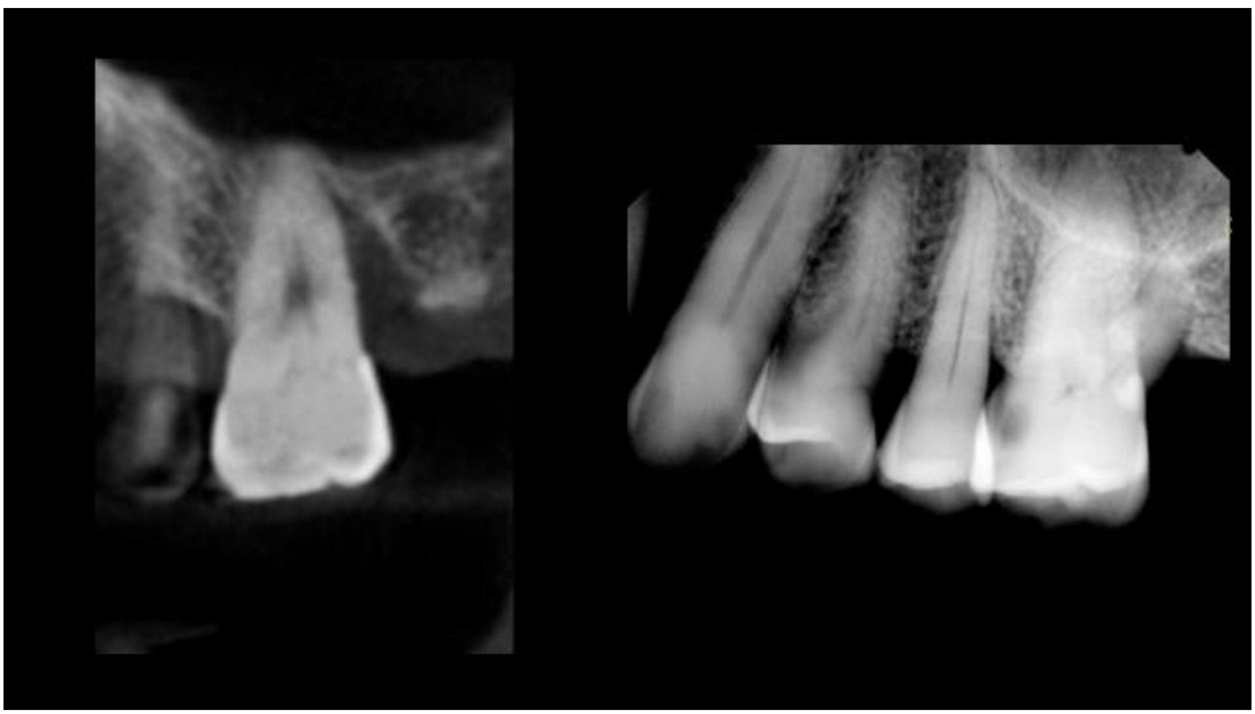
Fig 15. Distal vertical defect #14 CBCT (left) visible on PA (right)

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